



KG REDDY
College of Engineering
& Technology
AN AUTONOMOUS INSTITUTION

CELEBRATING
15
YEARS OF
BRILLIANCE

Highway Engineering Lab

LABORATORY MANUAL

Prepared By: Dr. K. Sai Kumar Chary, Associate Professor

**Department of Civil
Engineering**

Institute Vision

To become an institution which is internationally recognized for its holistic approach to engineering, innovative teaching and learning culture, research and entrepreneurial ecosystem, and sustainable social impact in the community.

Institute Mission

- To offer undergraduate and post-graduate programs which are supported through industry relevant curriculum and innovative teaching and learning processes that would help students succeed in their professional careers.
- To provide faculty and students with an ecosystem that fosters innovation, research, entrepreneurship, and international exposure through strategic partnerships with government organizations and collaboration with industries.
- To provide holistic learning environment to students which will contribute to their personal and professional growth and enable them to become leaders in their respective fields.
- To contribute to the development of the region by using our technological expertise to work with nearby communities and support them in their social and economic development

Department Vision

To be recognized for excellence in teaching, innovation, and research aimed towards betterment of society through sustainable infrastructural development.

Department Mission

- To integrate innovative teaching and learning practices that will enable students to build technical competence for working in civil engineering industries.
- To encourage innovation, research, and entrepreneurship among faculty and students that will lead to sustainable development.
- To become self-sustainable through strategic collaborations with industries and nearby communities focused on consultancy services.

Program Educational Objectives

PEO1: Graduates will be able to work in multidisciplinary teams focused on development of infrastructure, design, sustainability, construction management and all the other related fields of Civil Engineering.

PEO2: Graduates will be professionally competent through their ability to use modern civil engineering tools and manage projects in leadership positions.

PEO3: Graduates will transform into change makers who will work towards societal development and advocate for equity, social justice, and sustainable development.

Program Outcomes

PO1. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization for the solution of complex engineering problems.

PO2. Problem analysis: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for public health and safety, and cultural, societal, and environmental considerations.

PO4. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling to complex engineering activities, with an understanding of the limitations.

PO6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7.Environment and sustainability: Understand the impact of the professional Engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10.Communication: Communicate effectively on complex engineering activities with the engineering community and with the society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11.Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12.Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes

PSO1: Graduates will be able to plan, analyze, design safe and sustainable green infrastructure.

PSO2: Graduates will be able to utilize the latest software tools for modeling and simulation in the field of civil engineering.

PSO3: Graduates will be able to work in multidisciplinary teams to design, develop and promote smart construction related.

Highway Engineering Laboratory

Course Objectives: The objectives of this course for the student are to:

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1. To Determine the different tests of Highway material.
2. To Know the Engineering Properties of aggregates.
3. To Identify the grade and properties of Bitumen.
4. To Calculate the various traffic volume studies.
5. To know the design speed, Maximum speed limits of a location through the spot speed.

Course Outcomes: After completion of this course, the students will be able to

CO1: Identify quality control tests of Highway material.

CO2: Predict Engineering Properties of aggregates.

CO3: Identify the grade and properties of Bitumen.

CO4: Calculate the traffic volume.

CO5: Calculate the design speed, Maximum speed limits of a location through the spot speed

Department of Civil Engineering
Highway Engineering Laboratory

Course Code: KG23ACE321

B. Tech. III Year II - Semester

LIST OF EXPERIMENTS:

CYCLE – I

I. Road Aggregates:

1. Specific Gravity and Water Absorption.
2. Flakiness and elongation Indices of coarse Aggregates.
3. Aggregate Crushing value.
4. Aggregate Impact Test.
5. Abrasion Test.

II. Bituminous Materials:

6. Penetration Test.
7. Ductility Test.

CYCLE – II

II. Bituminous Materials:

1. Softening Point Test.
2. Flash and Fire Point Test
3. Marshal stability Test.

III. Traffic Studies

4. Traffic volume counts-Mid Blocks.
5. Traffic volume counts-Junctions.
6. Spot speed studies.
7. Parking Studies.

MANDATORY INSTRUCTIONS

1. Students should report to the labs concerned as per the timetable.
2. Record should be updated from time to time and the previous experiment must be signed by the faculty in charge concerned before attending the lab.
3. Students who turn up late to the labs will in no case be permitted to perform the experiment scheduled for the day.
4. After completion of the experiment, certification of the staff in-charge concerned in the observation book is necessary.
5. Students should bring a notebook of about 100 pages and should enter the readings/observations/results into the notebook while performing the experiment.
6. The record of observations along with the detailed experimental procedure of the experiment performed in the immediate previous session should be submitted and certified by the staff member in-charge.
7. The group-wise division made in the beginning should be adhered to, and no mix up of student among different groups will be permitted later.
8. The components required pertaining to the experiment should be collected from Lab- in-charge after duly filling in the requisition form.
9. When the experiment is completed, students should disconnect the setup made by them, and should return all the components/instruments taken for the purpose.
10. **Any damage of the equipment or burnout of components will be viewed seriously either by putting penalty or by dismissing the total group of students from the lab for the semester/year.**
11. Students should be present in the labs for the total scheduled duration.

12. Students are expected to prepare thoroughly to perform the experiment before coming to Laboratory.
13. Procedure sheets/data sheets provided to the students groups should be maintained neatly and are to be returned after the experiment.
14. DRESS CODE:
 - i. Boys - Formal dress with tuck in and shoes
 - ii. Girls - Formal dress
 - iii. **Apron for both boys and girls.**

ROAD AGGREGATES

Experiment No:1

Specific Gravity and Water Absorption.

IS 2386 (Part 3) - 1963

1.1 Aim: To determine specific gravity and water absorption of a given sample of coarse aggregate.

1.2 Apparatus: A wire basket of not more than 6-3 mm mesh, A stout watertight container in which the basket may be freely suspended, Thermostatically Controlled Oven, Glass vessel, Air tight container, 10 mm IS Sieve, Taping rod, Weighing Balance.

1.3 Precautions:

1. Keep in mind that the saturated surface dry sample is the condition when all the visible films of water are removed from the sample
2. All the weighing should be done carefully and accurately

1.4 Theory

Strength properties of road aggregates are indirectly related to its specific gravity and water absorption characteristics. In general, it observed that an aggregate having the high specific gravity and low water absorption would be dense, less porous, and durable and possess high strength.

Specific gravity is the ratio between the dry weights of aggregates in air to the weight of water equivalent to volume of the aggregate tested at a standard temperature.

Specific Gravity = Dry weight of the aggregates/ weight of water equivalent to the volume of the aggregates.

Water Absorption is the percentage by weight of water absorbed by the aggregates to the oven-dried weight of the aggregates at a standard temperature.

Water Absorption, (w %)

= (Weight of water absorbed by aggregates/Dry weight of the aggregates) * 100

1.5 Procedure:

1. Take 1000 gm of aggregate for each test in its natural state. Record the reading in the observation sheet as Weight W.
2. Now sieve the sample with 10 mm IS Sieve to remove the finer particles. Place the sieved sample in the glass vessel. Partly fill the vessel with the water. Keep the aggregates immersed for 24 hours at a temperature of 22 to 32 degrees Celsius, so that the aggregates are totally saturated.
3. After 24 hours, shake the vessel to remove the entrapped air. The vessel is then over filled with water. Keep a cap on the vessel so that no air enters the vessel. Note the weight of the vessel filled with water and aggregates and assume it as weight A
4. Remove all the water from the vessel and keep the aggregates on a cloth for surface dry condition.
5. Refill the vessel with distilled water and see to that no entrapped air present in the vessel. Weight the entire assemble and note it as weight B.
6. After the aggregates, which entrapped in the cloth, appeared to be in saturated surface dry condition, take the weight of the aggregates as Weight C.
7. The surface dry condition aggregates are kept in the oven for 24 hours at 100 degrees Celsius.
8. After 24 hours the aggregates are taken out from the oven and weight, Note this weight as Weight D.
9. Repeat the same procedure and record the values for the second sample of 1000 gm.
10. Immediately. after immersion the entrapped air shall be removed from the sample by lifting the basket containing it 25 mm above the base of the tank and allowing it to drop 25 times at the rate of about one drop per second. The basket and aggregate shall remain completely immersed during the operation and for a period of $24 \pm 1/2$ hours afterwards.

.6 Diagram:



1.7 Table And Calculation:

Description		Sample No	
		I	II
A	Weight of sample, g		
B	Weight of vessel + sample + water (A), g		
C	Weight of vessel + Water (B), g		
D	Weight of saturated & Surface dry sample (C), g		
E	Weight of oven dry sample (D), g		
F	Specific Gravity = [D / C - (A - B)]		
G	Apparent specific gravity = [D / D - (A - B)]		
H	Water Absorption, Percentage Dry Weight = [C - D / D]*100, %		
Average Values	Specific Gravity		
	Apparent Specific Gravity		
	Water Absorption		

- A = Wt of sample + vessel + water
 B = Wt of vessel and water
 C = Wt of saturated surface dry sample
 D = Wt of oven dry sample

1.8 Result:

1. The Specific Gravity of a given sample of coarse aggregate is found to be
2. The Water Absorption of a given sample of coarse aggregate is found to be %

EXPERIMENT- 2: FLAKINESS INDEX AND ELONGATION INDICES OF COARSE AGGREGATES.

IS 2386 (Part – I) – 1963; 2004

2.1 Aim:

To determination of Flakiness Index and Elongation Index of Coarse aggregates.

2.2 Apparatus:

The metal gauge shall be of the pattern shown in Fig. 10.1, Balance, Gauging Trowel, Stop Watch, etc.

2.3 Precautions:

1. Take the sample by quartering
2. Do not force to pass the particle from the thickness gauge
3. Measure the mass of aggregate retained accurately

2.4 Theory:

Generally, coarse aggregates may be in various shapes such as granular, spherical, cubical, flaky and elongated. Use of cubical shaped aggregates is good to attain high density and strength. Flaky and elongated aggregates are not useful because they break by loads easily.

Flaky shaped aggregates are measured using a thickness gauge (TG) and by determining the flakiness index (FI).

Elongated aggregates are measured using a length gauge (LG) and by determining the elongation index (EI)

FI & EI tests are not possible when the size of aggregates are less than 6.3 mm.

2.5 Procedure

Flakiness Test (FI)

FI of a given size of aggregate sample is expressed in terms of percentage by weight of aggregates, whose smallest dimension or thickness is less than $3/5$ or 0.6 times their average size. In other words, FI is the percentage by weight of flaky aggregates particles whose least thickness is less than 0.6 times the average size of the aggregates.

1. Sample - A quantity of aggregate shall be taken sufficient to provide the minimum number of 200 pieces of any fraction to be tested
2. The thickness gauge consists of a steel plate having 9 slots or openings of suitable dimensions by which an aggregate can be measured.
3. Following is the example for calculation the least dimension of the slot for TG for the size of aggregates used.
4. For an aggregate size in between 63 mm to 50 mm = $(0.6) * (63+50)/2 = 33.9$ mm.
5. The given sample is sieved through the standard sieves of nine sets
6. It is then checked whether each aggregate particles from all the sets passes through the slot designated.
7. The aggregates particles which pass through the respective slots are weighed separately.
8. FI may be calculated using the formula given below.

$$FI (\%) = (W2 / W1) * 100$$

Where

W1 = Total weight of the aggregates consider for the test.

W2 = Weights of various size of aggregates particles passed through the respective slots of TG, ie: 63-50 mm, 50-40 mm, 40-25 mm, 31.5-25 mm, 25-20 mm, 20-16 mm, 16-12.5 mm, 12.5-10 mm, and 10-6.3 mm.

Procedure

Elongation Test (EI)

EI of a given size of aggregate sample is expressed in terms of percentage by weight of aggregates whose longest dimension is more than 1.8 times their average size. In other words, EI is the percentage by weight of long aggregates particles whose length is more than 1.8 times the average size of the aggregates.

1. Sample - A quantity of aggregate shall be taken sufficient to provide the minimum number of 200 pieces of any fraction to be tested
2. The LG consists of a rectangular steel plate attached to a suitable size of wooden plate. Eight steel rods of suitable diameter are fixed in vertical direction in a row on the steel plate.
3. Following is the example for calculation the clear distance between successive rods according to the size of the aggregates used is shown below for aggregate sizes in between 50 mm to 40 mm = $(1.8) * ((50+40)/2) = 81.00$ mm.
4. The given sample is sieved through the standard sieves of seven sets
5. It is then checked whether each aggregate particles from all the sets passes through the rods designated.
6. The aggregates particles which not passed through the respective rods are weighed separately.
7. EI may be calculated using the formula given below.

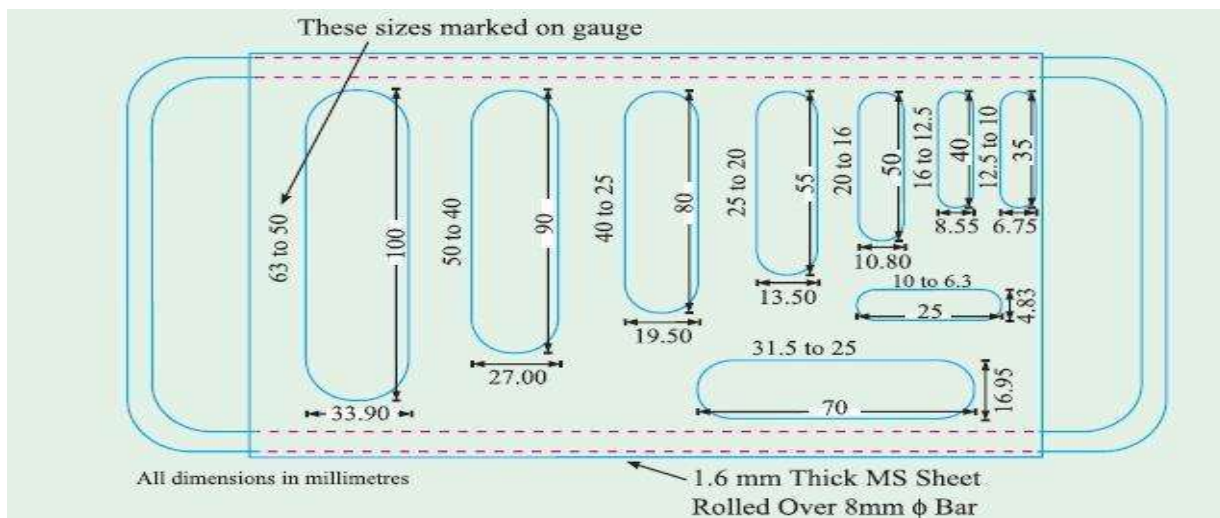
$$EI (\%) = (W2 / W1) * 100$$

Where

W1 = Total weight of the aggregates consider for the test.

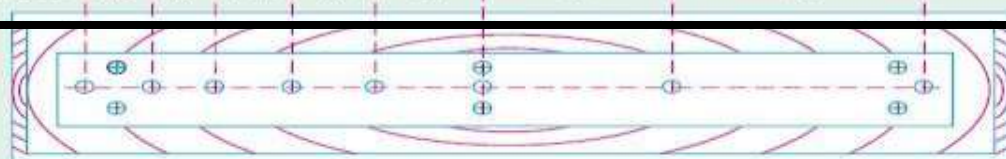
W2 = Weights of various size of aggregates particles which are not passed through the respective rods of LG, ie: 50-40 mm, 40-25 mm, 25-20 mm, 20-16 mm, 16-12.5 mm, 12.5-10 mm, and 10-6.3 mm.

2.6 Diagram:



Passing IS sieve	10	12.5	16	20	25	40	50
Retained IS sieve	6.3	10	12.5	16	20	25	40

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2.7 Table and Calculation:

Determination of Flakiness and Elongation Index of the Aggregate.

Total weight of sample W1 =

Size of aggregates							
Passing through IS Sieve in mm	Retained on IS Sieve in mm	Corresponding thickness gauge size in mm	Weight of aggregate passing through the thickness gauge		Corresponding length gauge size in mm	Weight of aggregate retained on the length gauge	
1	2	3	4 (Sample I)	5 (Sample II)	6	7 (Sample I)	8 (Sample II)
63	50	33.9			101.7	-	-
50	40	27			81		
40	25	19.5			58.5		
31.5	25	16.95			50.85	-	-
25	20	13.5			40.5		
20	16	10.8			32.4		
16	12.5	8.55			25.65		
12.5	10	6.75			20.25		
10	6.3	4.89			14.67		
Total (W2)		-			-		
FI or EI = (W2/W1)*100		-			-		
Average FI or EI		-			-		

Flakiness Index and Elongation Index, in excess of 35 to 40% is undesirable.

2.8 Result:

1. The flakiness index of a given sample of fine aggregate is %
2. The elongation index of a given sample of fine aggregate is%

EXPERIMENT - 3:

AGGREGATE CRUSHING VALUE

IS 2386 (Part 4) – 1963

3.1 Aim

To determine the Crushing Value of the given sample of Aggregates.

3.2 Apparatus

1. Steel cylinder with open ends and internal diameter 25.2 cm. Square base plate
2. Cylindrical measure having internal diameter of 11.5 cm and height 18 cm
3. Steel tamping rod with one rounded end, having a diameter of 1.6 cm and length 45cm to 60 cm
4. Balance of capacity of 3kg with accuracy up to 1gm
5. Compression testing machine of capacity 1000 KN
6. IS Sieves of sizes 12.5 mm, 10 mm and 2.36 mm

3.3 Principle

The principle mechanical properties required in road stones are

1. Satisfactory resistance to crushing under the roller during construction
2. Adequate resistance to surface abrasion under traffic

Aggregates used in road construction, should be strong enough to resist crushing under traffic wheel loads. If the aggregates are weak, the stability of the pavement structure is likely to be adversely affected. The strength of the coarse aggregates is assessed by aggregates crushing test.

The aggregate crushing value provides a relative measure of resistance to crushing under a gradually applied compressive load.

To achieve a high quality of pavement, aggregate possessing low crushing value should be preferred.

3.4 Procedure

1. Take the aggregates from the site and sieve. Collect the aggregates passing 12.5 mm sieve and retained on 10 mm sieve by using the manual way of sieving.
2. We require 6.5 Kg of aggregates for two tests. After the aggregates is collected, it is weighed on the balance. Take 3 kg of sample for one test.

3. To avoid any error due to the presence of moisture, the aggregate is heated in the oven at a temperature of 100 degree Celsius to 110 degree Celsius and is then cooled to room temperature.
4. The cylinder is then filled with the dry sample with three equal layers. After each layer, tamping should be done with 25 blows. The top surface should be levelled off with the tamping rod.
5. The total aggregate, which is required to fill the cylinder, is weighed and is recorded as W1.
6. The measured aggregates are filled in the test cylinder with a base Plate. This should be done in the similar manner of three layers with 25 tamping's each. The top surface is leveled and the cap is fixed with the plunger.
7. The testing plate with the plunger is well placed in to the Compression testing machine. The level of the cylinder is so adjusted; that the top surface of the plunger is just touched the surface of the aggregates.
8. Start the machine and apply the load of 40 Tones, with a rate of four Tones/ Minute. After the load reached the desired level, release the load with the help of valve.
9. The crushed aggregates in the cylinder are transferred into the 2.36 mm sieve. Do the sieving manually and collect the material passed by the 2.36 mm sieve. The fines collected from the sieving is weighed and is recorded as W2.
10. The test is repeated for the second time and the value is recorded.

3.5 Diagram:



3.6 Observation Table and Calculation:

The ratio of the weight of fines formed to the total sample weight in each test shall be expressed as a percentage, the result being recorded to the first decimal place:

$$\text{Aggregate Crushing Value (\%)} = (W2/W1) \times 100$$

W1 = weight of the compacted aggregate filled in the test mould in gm.

W2 = Weight of the aggregate powder passing through a 2.36 mm size sieve in gm.

The average crushing values obtained in different trails is the aggregate crushing value.

Sample No	W1	W2	(W2/W1) X 100	AC Value %
1				
2				
Average				

3.7 Result

The aggregate crushing value of given sample of coarse aggregate is %

EXPERIMENT -4: AGGREGATE IMPACT VALUE

IS 2386 (Part 4) - 1963

4.1 Aim: This method of test covers the procedure for determining the aggregate impact value of coarse aggregate.

4.2 Apparatus: An Impact testing machine.

1. A cylindrical steel cup of internal dimensions: Diameter 102 mm, Depth 50 mm and not less than 6.3 mm thick (W)
2. A metal hammer weighing 13.5 to 14.0 kg, the lower end of which shall be cylindrical in shape, 100.0 mm in diameter and 5 cm long, with a 2 mm chamfer at the lower edge, and case-hardened. The hammer shall slide freely between vertical guides so arranged that the lower (cylindrical) part of the hammer is above and concentric with the cup.
3. Means for raising the hammer and allowing it to fall freely between the vertical guides from a height of 380.0 mm on to the test sample in the cup, and means for adjusting the height of fall within 5 mm.
4. Sieves-The IS Sieves of sizes 12.5, 10 and 2.36 mm, Tamping Rod, balance of capacity not less than 500 g, Oven etc.

4.3 Precautions:

1. Proper sieve should be used for preparing the sample
2. Please ensure that the metallic cup is tightly bolted
3. The safety lock should always be in position
4. Measure all quantities to the accuracy of 1 in 1000.

4.4 Theory:

Repetitive traffic wheel loads cause damage to the pavement layers by compression, impact and abrasion. AI Value is expressed as the percentage of aggregate powder formed under impact loads in standard test conditions.

4.5 Procedure:

1. The test sample shall consist of aggregate the whole of which passes a 12.5 mm IS Sieve and is retained on a 10 mm IS Sieve. The aggregate comprising the test sample shall be dried in an oven for a period of four hours at a temperature of 100 to 110°C for 4 hours and cooled.
2. The measure shall be filled about one-third full with the aggregate and tamped with 25 strokes of

the rounded end of the tamping rod. The net weight of aggregate in the measure shall be determined to the nearest gram (Weight W1)

3. The impact machine shall rest without wedging or packing upon the level plate, block or floor, so that it is rigid and the hammer guide columns are vertical.

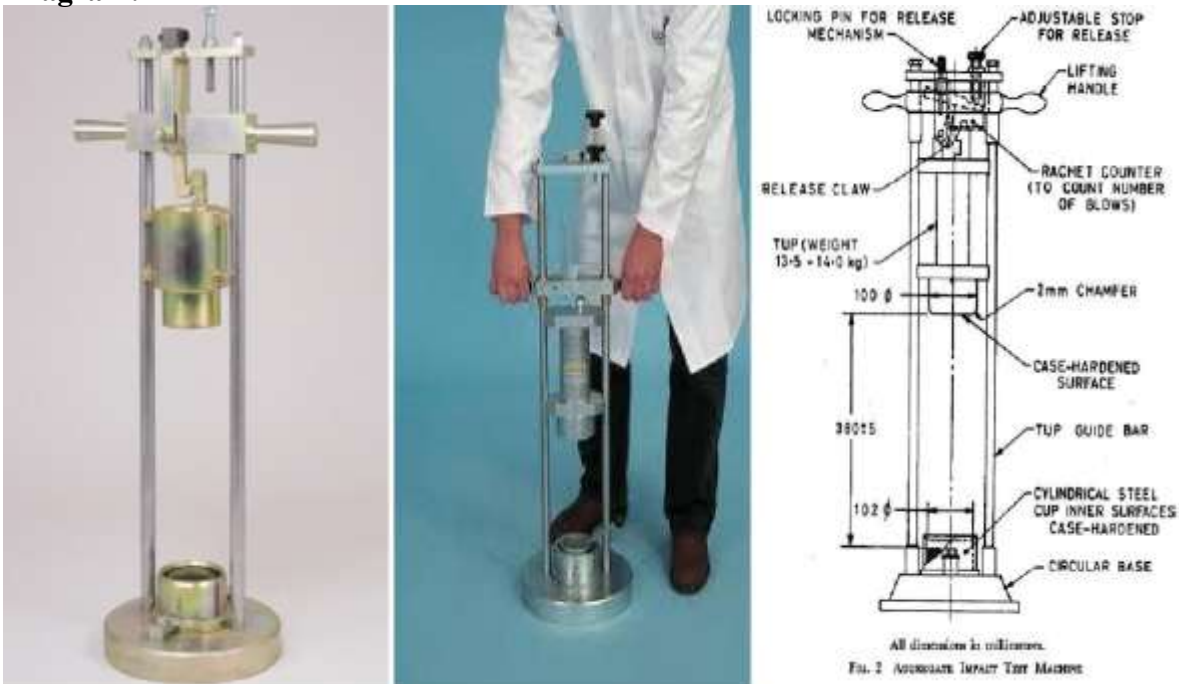
4. The cup shall be fixed firmly in position on the base of the machine and the whole of the test sample placed in it and compacted by a single tamping of 25 strokes of the tamping rod.

5. The hammer shall be raised until its lower face is 380 mm above the upper surface of the aggregate in the cup, and allowed to fall freely on to the aggregate. The test sample shall be subjected to a total of 15 such blows each being delivered at an interval of not less than one second.

6. The crushed aggregate shall then be removed from the cup and the whole of it sieved on the 2.36 mm IS Sieve until no further significant amount passes in one minute. The fraction passing the sieve shall be weighed to an accuracy of 0.1 g (Weight W2).

7. Two tests shall be made.

4.6 Diagram:



4.7 Table and Calculation:

Aggregate Impact Value = $W2/W1 \times 100$

W1 = weight of the compacted aggregate filled in the test mould in gm.

W2 = Weight of the aggregate powder passing through a 2.36 mm size sieve in gm.

Sample No	W1	W2	(W2/W1) X 100	AI Value %
1				
2				
Average				

4.8 Result:

The aggregate Impact value of given sample of coarse aggregate is %

The aggregate impact value should not be more than 45 per cent for aggregate used for concrete other than for wearing surfaces, and 30 per cent for concrete used for wearing surfaces such a runways, roads and air field pavements.

4.9 Remarks:

IRC recommends that the aggregate crushing value is restricted to 30% for concrete used roads and 45% for other concrete structures.

Exceptionally Strong	AI < 10%
Strong	AI 10 – 20 %
Satisfactory	AI 10 – 30 %
Weak	AI > 35 %

Bituminous Concrete	24%
Semi Dense Bituminous Macadam, DBM	27 %
BM, WBM, Surface Dressing,	30 %
Concreting wearing surfaces	30 %
Concreting Other than wearing surface	45%

EXPERIMENT-5: ABRASION TEST

IS 2386(Part 4) – 1963; 2005

5.1 Aim: To determine the Abrasion value of coarse aggregate by using the Los Angeles Abrasion machine.

5.2 Apparatus:

1. Los Angeles machine - The Los Angeles abrasion testing machine consist of a hollow steel cylinder, closed at both ends, having an inside diameter of 700 mm and an inside length of 500 mm. The cylinder shall be mounted on stub shafts attached to the ends of the cylinders but not entering it, and shall be mounted in such, a manner that it may be rotated about its axis in a horizontal position.
2. An opening in the cylinder is provided for the introduction of the test sample.
3. A removable steel shelf, projecting radially 88 mm into the cylinder and extending its full length, mounted along one element of the interior surface of the cylinder. The shelf of such thickness and mounted, by bolts or other approved means, as to be firm and rigid..
4. 12 Steels balls of diameter 48 mm and weight 445 grams. The number of steel balls for each test depends on the grading we use.
5. Electronic balance
6. IS Sieve 1.7 mm, Other sieves Ranging from 2.36 mm to 80 mm.

5.3 Theory:

The property of hardness or resistance to withstand the combined effect of abrasion and impact forces by repetitive wheel load are evaluated in the Los Angels Abrasion Test. The friction between the tyre and the road results in the abrasion of the aggregates. The aggregates should bear enough resistance against abrasion.

Table 4.1: Grading Of Aggregates.

Sieve size (square Hole)/Passing retained on		Wt in grams test sample, for grade							Remarks
mm	mm	A	B	C	D	E	F	G	
80	63	-	-	-	-	2500	-	-	
63	50	-	-	-	-	2500	-	-	
50	40	-	-	-	-	5000	5000	-	
40	25	1250	-	-	-	-	5000	5000	
25	20	1250	-	-	-	-	-	5000	
20	12.5	1250	2500	-	-	-	-	-	
12.5	10.0	1250	2500	-	-	-	-	-	
10.0	6.3	-	-	2500	-	-	-	-	
6.3	4.75	-	-	2500	-	-	-	-	
4.75	2.36	-	-	-	5000	-	-	-	
No of Steel balls		12	11	8	6	2	12	12	
No Of Revelations		500	500	500	500	1000	1000	1000	

Generally for WBM : Grading E and for SDBC : Grading B, C, D will be used.

5.4 Procedure:

1. The test sample shall consist of clean aggregate, which has been dried in an oven at 105°C to 110°C for four hours. Take the constant weight of the aggregates and shall conform to one of the grading in A,B,C,D,E,F,G based on the type of construction work.
2. Measure the exact weight of the aggregate and note down the values.
3. The test sample and the abrasive charge should be placed in the Los Angeles abrasion testing machine and the machine rotated at a speed of 30 to 33 rev/ min. For grading A, B, C and D, the machine shall be rotated for 500 revolutions; for grading E, F and G, it shall be rotated for 1000 revolutions.
4. The machine shall be so driven and so counter-balanced as to maintain a uniform peripheral speed.
5. At the completion of the test, open the steel cover; remove the crushed material to a pan of size 8.8 cm x 2.5 cm x 70 cm. Separate the steel balls from the material.
6. Sieve the material with 1.7 mm, weight the fraction passing through the sieve of 1.7 mm. On the other side, check the weight coarser than 1.7 mm.

7. Repeat the test for the second sample, and consider the mean value as Los Angles Abrasion Value.
8. The Los Angles Abrasion value is expressed in terms of percentage by weight of stone powder passing through a 1.70 mm sieve to the total weight of the aggregate sample taken for the test.

5.5 Diagram:



5.6 Table and Calculation:

- A = weight in gm of saturated surface - dry sample
- B = weight in gm of fraction passing through 1.70 mm IS Sieves.

Aggregate abrasion value = $(B / A) \times 100$.

Table 5.2: Observation Table

	A	B	Abrasion Value = (B / A) X 100
Sample 1			
Sample 2			
Mean	-	-	

Table 5.3: Interpretation of Results

Sr.No	Type of Pavement Layer	Max Permissible Abrasion Value in %
1	WBM, Sub base course	40
2	Base courses with WBM, WMM, BM	40
3	Bituminous Surface Dressing	35
4	Dense graded bituminous macadam and semi dense graded Bituminous Concrete	35
5	Bituminous Concrete and CC Pavements	30

5.7 Result:

The Aggregate Abrasion Value of given sample of coarse aggregate is %

II. BITUMINOUS MATERIALS

EXPERIMENT-1: PENETRATION TEST

1.1 AIM: To determine the grade of given bitumen sample by the checking the consistency.

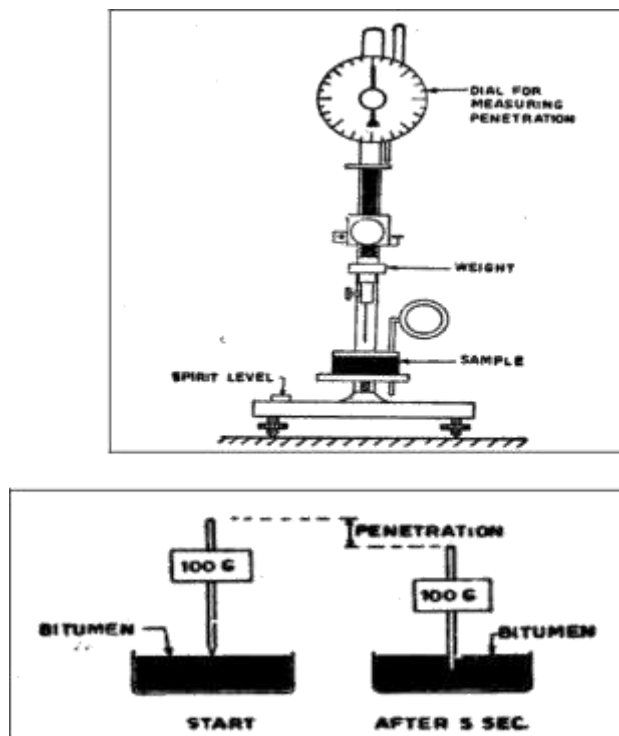
1.2 APPARATUS:

It consists of needle, water bath, penetrometer, and stopwatch. Container is 55 mm in diameter and 35mm to 57mm height. The needle is provided with a shank approximately 3.0mm in diameter into which it is immovably fixed.

1.3 PRECAUTIONS:

1. Be careful while doing the test as it the bitumen is very hot.
2. The heating should be done very carefully
3. Measure all quantities very accurately.

1.4 DIAGRAM:



1.5 PROCEDURE:

1. The bitumen is softened to a paving consistency between 75° and 100°C above the approximate temperature at which bitumen softens.
2. The sample material is thoroughly stirred to make it homogeneous and free from air bubbles and water.
3. The sample containers are cooled in atmosphere of temperature not lower than 25°C for one hour. Then they are placed in temperature controlled water bath at a temperature of 25°C for a period of one hour to one and half hour.
4. The weight of needle, shaft and additional weight are checked. The total weight of this assembly should be 100gm.
5. Using the adjusting screw, the needle assembly is lowered and the tip of the needle is made to just touch the top surface of the sample.
6. The needle assembly is clamped in position. The contact of the tip of the needle is checked using the mirror placed on the rear of the needle.
7. The initial reading of the penetrometer dial is either adjusted to zero or the initial reading is noted.
8. Then the needle is released by pressing a button and a stop watch is started. The needle is released exactly for a period of 5.0 secs.
9. At least 3 measurements are made on this sample by testing at distance of not less than 10 mm apart and 10 mm away from the boundry.
10. The difference between the initial and final penetration readings are taken as the penetration value.

1.6 TABLE AND CALCULATION:

Readings	Trails			Mean Value
	1	2	3	
Penetrometer Dial, Initial Reading				
Penetrometer Dial, Final Reading				
Penetration Value				

1.7 Grades of Bitumen IS: 73-1992

For example, if the bitumen sample is graded as 30/40, it means that the penetration of the needle is in the range of 30 to 40 times of one-tenth of millimeter. (3 to 4 mm)

Grade	Penetration in mm
S-35	30/40
S-45	40/50
S-55	50/60
S-65	60/70
S-90	80/100
S-200	175/225

1.8 RESULT:

The average penetration value of a given bitumen sample is _____ and the grade of bitumen is _____.

EXPERIMENT -2: DUCTILITY TEST

2.1 AIM: To conduct ductility test on given bitumen sample.

2.2 APPARATUS: 3 Nos of Briquette moulds, (length – 75mm, distance between clips – 30mm, width at mouth of clips – 20mm, cross section at minimum width – 10mm x 10mm), Ductility machine with water bath and a pulling device at a pre calibrated rate, a putty knife, thermometer.

2.3 PRECAUTIONS:

1. Be careful while doing the test as it the bitumen is very hot.
2. The heating should be done very carefully
3. Measure all quantities very accurately.

2.4 THEORY: Ductility of a material is the property by virtue of which it can be pulled without breaking a part. It should be ductile, because it should take up the deformation.

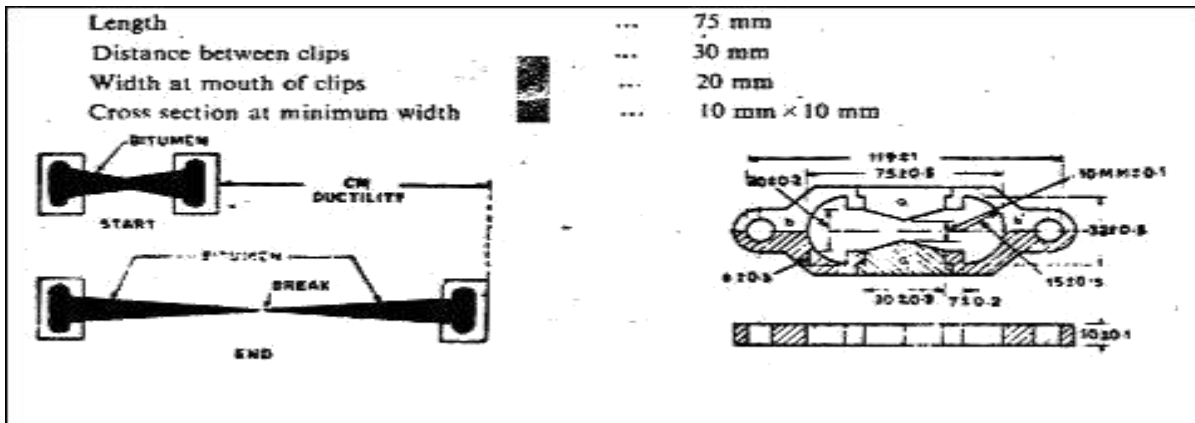
2.5 PROCEDURE:

1. Heat the bitumen sample is at a temperature of (75°C to 100°C) and poured into the mould assembly and placed on a brass plate, where a solution of glycerin or soap solution is applied at all surfaces of briquette mould exposed to bitumen.
2. After the sample is poured into the mould, allow it to cool in air for thirty to forty minutes. Then the entire assembly is placed in a water bath at 27°C for thirty minutes.
3. The moulds should be placed in the Ductility water bath.
4. The pointer is set to read zero. The machine is started and the two clips are thus pulled apart horizontally. One end is fixed and the other is pulled apart.
5. While the test is in operation, it is checked whether the sample is immersed in water at depth of at least 10mm. The distance at which the bitumen thread of each specimen breaks is recorded (in cm) to report as ductility value.

6. Note down the breaking value of all the three samples. The mean of all the values is ductility value.

7. If the bitumen does not break even after 75 cm then the value is noted as greater than 75.

2.6 DIAGRAM:



2.7 TABLE AND CALCULATION:

Test Property	Trails			Mean Value
	1	2	3	
Ductility Value				

Grade	Ductility Minimum in cm
S - 35	50
S - 55	75
S - 65	75
S - 90	75
S - 200	75

2.8 RESULT:

The ductility value of the given bitumen sample is _____ cm.

EXPERIMENT -3: SOFTENING POINT (Ring and Ball Apparatus)

3.1 AIM: To determine the softening point of given paving bitumen as per IS: 1205 – 2002.

3.2 APPARATUS: Ring and Ball apparatus, Water bath with stirrer, Thermometer, Glycerin, etc. Steel balls each of 9.5 mm and weight of $2.5 \pm 0.08\text{gm}$.

3.3 PRECAUTIONS:

1. Be careful while doing the test as it the bitumen is very hot.
2. The heating should be done very carefully
3. Measure all quantities very accurately.

3.4 THEORY:

Softening point is the measure of temperature at which the bitumen will acquire a degree of softening. A steel ball passes through a mould at a height of 2.5 cm when heated under water.

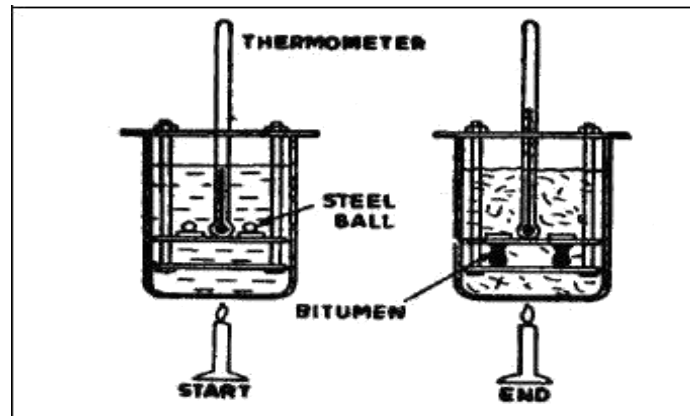
In this experiment If the softening point of the bitumen is high, it indicates a harder grade of bitumen and if it is low, it indicates softer grades of bitumen. The value of softening point is very useful in determining the penetration index, temperature susceptibility, temperature shear resistance and other visco – elastic properties of bitumen. According to IS: 73-2006, the minimum temperature of the softening point for paving bitumen of grades VG 10, VG 20, VG 30, VG 40 should be 40,45,47, 50°C

3.5 PROCEDURE:

1. Sample material is heated to a temperature between 75° and 100°C above the approximate softening point until it is completely fluid and is poured in heated rings placed on the metal plate.
2. To avoid sticking of the bitumen to metal plate, coating is done to this with a solution of glycerin and dextrin.
3. After cooling the rings in air for 30 minutes, the excess bitumen is trimmed and rings are placed in the support.
4. Steel spears of weight 3.5 gm and diameter 9.5mm are placed over the bitumen filled brass rings.

5. At this time the temperature of distilled water is kept at 5°C. This temperature is maintained for 15 minutes after which the balls are placed in position.
6. The height of the water should be 50mm above the steel spears and the vertical distance between the two plates of the frame should be 25 mm.
7. Then the temperature of water is raised at uniform rate of 5°C per minute with a controlled heating unit, until the bitumen softens and touches the bottom plate by sinking of balls. At least two observations are made.
8. The temperature at the instant when each of the ball and sample touches the bottom plate of support is recorded as softening point value.
9. If the softening point is higher than 80°C then it should be heated in glycerin but not in water with initial temperature as 35 °C
10. If the difference between the I and II ball temperature difference should not exceed 1-2 °C. If it so, the test need to be repeated again.

3.6 DIAGRAM:



Softening Test Concept

3.7 TABLE AND CALCULATION:

Test Property	Trails			Mean Value
	1	2	3	
Temperature (°C) at which I ball touches the bottom plate				

Temperature ($^{\circ}\text{C}$) at which II ball touches the bottom plate				
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3.8 RESULT:

The softening point value of given bitumen sample is _____ $^{\circ}\text{C}$ and grade of bitumen is _____.

EXPERIMENT -4: FLASH & FIRE POINT TEST

4.1 Aim:

To determine the flash and fire point of a given bituminous material.

4.2 Apparatus:

Pensky-Martens closed cup tester, thermometer, heating source, flame exposure.

4.3 Procedure:

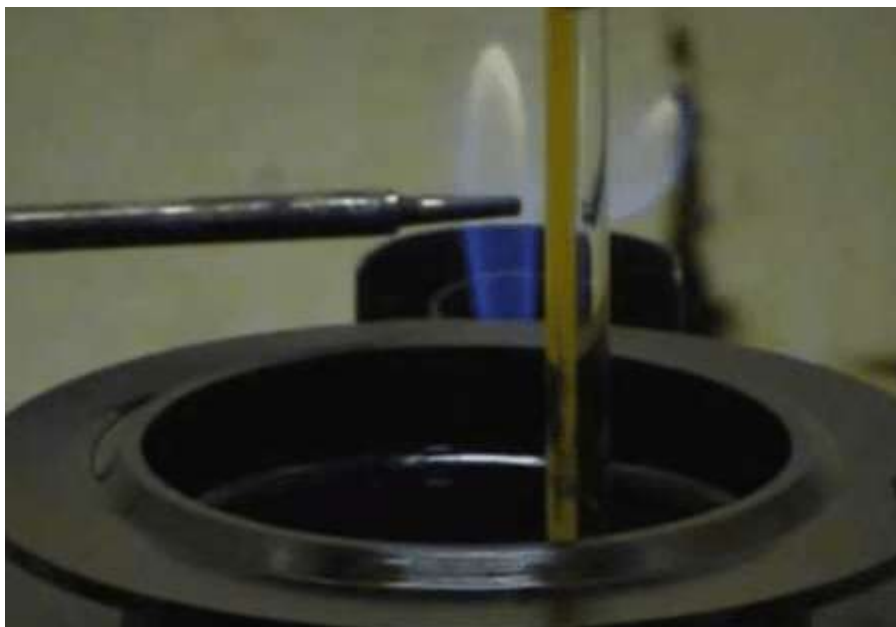
1. All parts of the cup are cleaned and dried thoroughly before the test is started.
2. The material is filled in the cup upto a mark. The lid is placed to close the cup in a closed system. All accessories including thermometer of the specified range are suitably fixed.
3. The bitumen sample is then heated. The test flame is lit and adjusted in such a way that the size of a bed is of 4mm diameter. The heating of sample is done at a rate of 5° to 6°C per minute. During heating the sample the stirring is done at a rate of approximately 60 revolutions per minute.
4. The test flame is applied at intervals depending upon the expected flash and fire points And corresponding temperatures at which the material shows the sign of flash and fire are noted

4.4 Theory and Scope:

Flash and Fire point test is a safety test conducted on a bituminous material so that it gives an indication of the critical temperature at and above where precautions should be taken to eliminate fire hazards during its applications. Bituminous materials leave out volatiles at high temperature depending upon their grade. These volatile vapors catch fire causing a flash.

This condition is very hazardous and it is therefore essential to qualify this temperature for each bitumen grade, so that the paving engineers may restrict the mixing or application temperature well within the limits. Flash and Fire point test is conducted as per IS: 1209.

As per IS: 1209 the definitions of flash and fire point are: Flash Point: "The flash point of a material is the lowest temperature at which the vapour of substance momentarily takes fire in the form of a flash under specified conditions of test". Fire Point: "The fire point is the lowest temperature at which the material gets ignited and burns under specified condition of test"



4.5 TABLE AND CALCULATION:

Test Property	Trails			Mean Value
	1	2	3	
Flash Point				
Fire Point				

4.6 RESULT:

The temperature at which the flame application that causes a bright flash _____⁰C

Temperature at which the sample catches fire _____⁰C

EXPERIMENT -5: MARSHAL STABILITY TEST.

Aim:

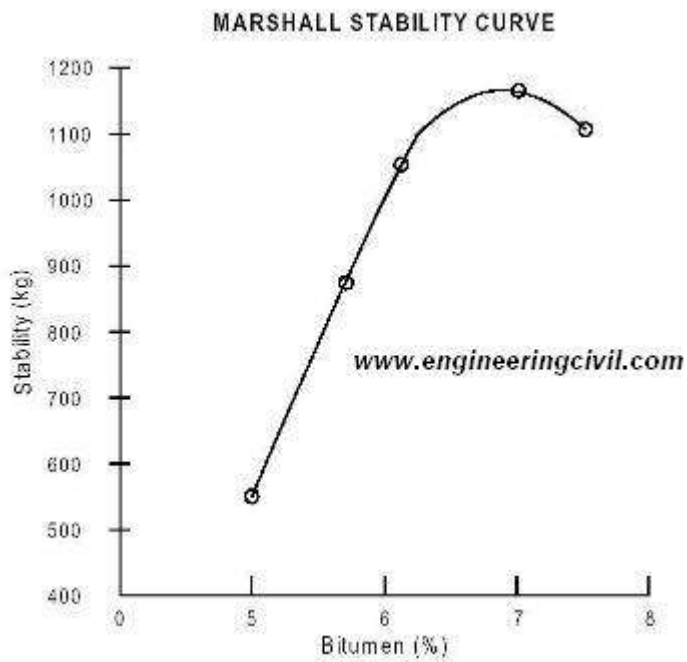
This test is done to determine the Marshall stability of bituminous mixture as per ASTM D 1559. The principle of this test is that Marshall Stability is the resistance to plastic flow of cylindrical specimens of a bituminous mixture loaded on the lateral surface. It is the load carrying capacity of the mix at 60°C and is measured in kg.

Apparatus:

- i) Marshall stability apparatus
- ii) Balance and water bath

Procedure

- i) Heat the weighed aggregates and the bitumen separately upto 170°C and 163°C respectively.
- ii) Mix them thoroughly, transfer the mixed material to the compaction mould arranged on the compaction pedestal.
- iii) Give 75 blows on the top side of the specimen mix with a standard hammer (45cm, 4.86kg). Reverse the specimen and give 75 blows again. Take the mould with the specimen and cool it for a few minutes.
- iv) Remove the specimen from the mould by gentle pushing. Mark the specimen and cure it at room temperature, overnight.
- v) A series of specimens are prepared by a similar method with varying quantities of bitumen content, with an increment of 0.5% (3 specimens) or 1 bitumen content.
- vi) Before testing of the mould, keep the mould in the water bath having a temperature of 60°C for half an hour.
- vii) Check the stability of the mould on the Marshall Stability apparatus.



RESULTS

Plot % of bitumen content on the X-axis and stability in kg on the Y-axis to get maximum Marshall stability of the bitumen mix. A sample plot is given

III. TRAFFIC STUDIES

1. Traffic volume counts-Mid Blocks & Junctions

Aim: To conduct a traffic volume study using pneumatic tubes and to determine different volume statistics for a particular road section.

Apparatus:

1. Pneumatic Tubes
2. Accessories (nails/bolts, hammer, holding strips, etc.)
3. Air switches
4. Data Analyzer (Computer System)

THEORY

Automatic recording Today, thousands of permanent detectors are installed on freeways, at intersections and other locations. These detectors provide the opportunity to gather large amounts of data on the traffic system. The difficulty is that much of the data is only available in real time that is, it is not permanently stored in the retrievable form, and the variety of technologies in use makes it difficult to coordinate everything into a seamless system of critical information on the system.

Automatic count recording methods Automatic counts are recorded using one of the following three methods:

1. Portable Counters
2. Permanent Counters
3. Videotape Portable Counters

Portable counting is a form of manual observation. Portable counters serve the same purpose as manual counts but with automatic counting equipment. The period of data collection using this method is usually longer than when using manual counts. The portable counter method is mainly used for 24- hour counts. Pneumatic road tubes are used to conduct this type of automatic counts

Permanent Counters: Permanent counters are used when long-term counts are to be conducted. The counts could be performed every day for a year or more. The data collected may be used to monitor and evaluate traffic volumes and trends over a long period of time. Permanent counters are not a cost-effective option in most situations. Few jurisdictions have access to this equipment Observers can record count data by videotaping traffic. Traffic

volumes can be counted by viewing videotapes recorded with a camera at a collection site. A digital clock in the video image can prove useful in noting time intervals. Videotaping is not a cost-effective option in most situations. Not many jurisdictions have access to this equipment. Pneumatic Tube-based counter A pneumatic road tube is a closed-end tube in which air pressure is maintained. When stretched across a roadway, a vehicle (actually an axle) rolling over it creates an air pulse that travels through the tube, which is connected to some form of the data capture device. Such tubes are most often used for traffic counting, but they can also be used to measure speed. Pair of tubes can be used to measure speed, the recording devices measures the elapsed time between the actuation of the first and second tubes. Although a variety of traffic counters are available to use with road tubes, the most common types record a total count at preset intervals, so that 5, 10, 15 and 60-minute counts can be automatically recorded.

Important features of automatic recording

1. Counting is done by sophisticated electronic devices, sensors, and detectors.
2. Used for gathering a large amount of traffic data.
3. Used when the effort and expense of automated equipment are justified.
4. Counting is usually done in 1-hour intervals for each 24-hour period.
5. Counting may be done continuously for a week, month or a year.
6. It is a fit-and-forget type of instrument.

PROCEDURE

1. First, a section of road is selected according to the guidelines where pneumatic tubes can be properly placed and they are checked for any cut, scratch, etc.
2. Pneumatic tubes are then placed on top of the leveled road surface at the selected section.
3. The tubes are held in place with the help of fastening strips. These strips are secured into the road pavement using nails/bolts by means of a hammer.
4. These are connected to air switches which in-turn, are connected to a traffic counting device.
5. The sensor is checked for proper working.
6. The traffic counting device is placed at an appropriate place where it is safe and secure (preferably off the road corridor).
7. When a vehicle passes over the tube, due to compression, change in air pressure is sent to the air switch which activates the traffic counting device. Air switches provide accurate axle counts and data is recorded by the counting device for every vehicle which passes. The

internal mechanism of the air compressed records classified vehicle count. The direction is also recorded when a pair of tubes are placed on the road, depending on which tube is crossed first.

8. Data for the whole study duration is collected automatically, without the continuous involvement of the observer.

9. Data and results can be obtained by connecting the counting device to a computer using the software. From the recorded data, calculate hourly volume, ADT, AADT and Peak Hour Factor for each direction.

OBSERVATIONS

$$PCU, \text{ vehicles} = \text{Number of vehicles} \times PCU \text{ factor}$$

CALCULATIONS

Volume =

$$\frac{\text{total no. of PCU/hr vehicles}}{\text{total time}}$$

$$\text{Peak hourfact} = \frac{\text{total hourly volume}}{4 \times \text{maximum 15 minute volume within the hour}}$$

Traffic Volume Counts-Junctions

Date and Day of the Week:							Road Classification:		
Direction of Traffic:			From:		To:	Kilometer/Mileage:			
						Route Number:			
						District:			
						State:			
Hour of Count	Motor cycle or scooter, Cycle	Passenger Car, Auto Rickshaw	Truck or Bus or Hand Cart	Truck Trailer or Agricultural Tractor	Cycle Rickshaw	Horse Drawn Vehicle	Bullock Cart	Total PCUs	
From _____	0.50	1.00	3.00	4.50	2.00	4.00	8.00		
Hours to _____									
Hours									
Vehicles Turning Left									
Vehicles Proceeding Straight Ahead									
Vehicles Turning Right									
Hourly Total Vehicles									
PCU Calculation									
Hourly PCU									

Traffic Volume Counts-Junctions

Date and Day of the Week:							Road Classification:		
Direction of Traffic:				From:		To:	Kilometer/Mileage :		
							Route Number:		
							District:		
							State:		
Hour of Count	Motor cycle or scooter, Cycle	Passenger Car, Auto Rickshaw	Truck or Bus or Hand Cart	Truck Trailer or Agricultural Tractor	Cycle Rickshaw	Horse Drawn Vehicle	Bull Cart	Total PCUs	
From _____	0.50	1.00	3.00	4.50	2.00	4.00	8.00		
Hours to _____									
Hours									
Vehicles Turning Left									
Vehicles Proceeding Straight Ahead									
Vehicles Turning Right									
Hourly Total Vehicles									
PCU Calculation									

Hourly PCU	
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Name and Signature of the Enumerator with Date:

Name and Signature of the Supervisor with Date:

Name and Signature of the Enumerator with Date:

Name and Signature of the Supervisor with Date:

Spot Speed Studies.							
Name of the Road:			From:		To:		
From KM:		To KM:			No of Trip:		
Date and Time:							
Sl. No	Vehicle Type	Distance in Kilometers & Meters.	Control Points	First Stop Watch in Minutes & Seconds	Second Stop Watch in Minutes & Seconds	Time Duration in Minutes & Seconds	Spot Speed in KMPH
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
Average Spot Speed							

Name and Signature of the Enumerator with Date:

Name and Signature of the Supervisor with Date:

Name and Signature of the Enumerator with Date:

Name and Signature of the Supervisor with Date:

Parking Accumulation	
Parking Volume	
Parking Load	
Parking Duration	
Parking Index	
Parking Turnover	



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